AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 108:91–96 (1999)

# The Form of the Supraorbital Margin as a Criterion in Identification of Sex From the Skull: Investigations Based on Modern Human Skulls

MATTHIAS GRAW,[1]* ALFRED CZARNETZKI,[2]
AND HANS-THOMAS HAFFNER[3]
[1]*Institute of Forensic Medicine, University of Tübingen, 72074 Tübingen, Germany*
[2]*Osteology Collection, University of Tübingen, 72002 Tübingen, Germany*
[3]*Institute of Forensic Medicine, University of Essen, 45122 Essen, Germany*

*KEY WORDS* sexual dimorphism; modern humans; skull; supraorbital margin; identification

*ABSTRACT* Sexual dimorphism in the shape of the supraorbital margin was reported by Broca and various subsequent authors, but no consistently applied, precise definition has been established. In this study of modern human skulls, the value of our definition of the sex-related difference in this area in the identification of sex from the skull was investigated. It was found that this feature can be assessed reliably, is strongly related to sex, and is independent of the side. The accuracy of identification of sex using this method alone was found to be about 70%. Am J Phys Anthropol 108:91–96, 1999. 

In addition to the estimation of age, the identification of sex from human remains is of fundamental importance in forensic medicine and anthropology. Identification of sex from the skeleton is based on differences in shape and size, although the fact that these may be subject to racial influences also has to be taken into account. The skeletal components most often investigated for this purpose are the pelvis and skull. A number of authors include the "sharpness" of the supraorbital margin in females first described by Broca (1875) (Table 1) amongst the sex-related differences in the skull. As suggested by Pietrusewsky (personal communication), we found that it is not the magnitude of this prominence (i.e., the impression of sharpness on palpation because of reduced thickness) that is important but rather whether the supraorbital margin exhibits an evenly rounded trough shape in cross-section for part of its length (male) or whether the inner aspect is angular along the whole of its length (female) (Graw et al., 1997).

## MATERIALS AND METHODS

To determine whether this feature could be of use in the identification of sex from the skull in modern humans (in forensic work, for example) we investigated 108 skulls (from 67 males and 41 females). Death had occurred during the years 1964–1994, and age at death was evenly distributed (Table 2). All specimens were derived from southwest Germany.

Our previous experience had shown inspection or palpation alone to be unreliable for assessment of the contours of the supraorbital margin. Quick, reproducible findings had been found to be obtained by making a plasticine impression of this structure (Figs. 1, 2) (Graw et al., 1997). A rectangular piece of plasticine is pressed onto the supraorbital margin to produce an impression of its contours. The plasticine is then removed care-

*Correspondence to: Matthias Graw, Institut für Gerichtliche Medizin, Nägelestr. 5, D-72074 Tübingen, Germany. E-mail: matthias.graw@uni-tuebingen.de

Received 6 December 1997; accepted 12 September 1998.

*TABLE 1. References to sexual dimorphism of the supraorbital margin*

| Authors | Male morphology (♂) | Female morphology (♀) |
|---|---|---|
| Broca (1875) | Supraorbital margin thicker | Sharpness of the outer supraorbital margin |
| Rebentisch (1893) | Outer supraorbital margin wide/very wide | Outer supraorbital margin thin, sharper edged |
| Voigt (1941) | Outer supraorbital margin nondescript | Outer supraorbital margin tends to be thin |
| Krogmann (1962) | Orbits with rounded margins | Orbits with sharp margins |
| Acsádi and Nemskéri (1970) | Supraorbital margin heavy, protruding, rounded | Supraorbital margin thin, sharp |
| Hunger and Leopold (1978) | Supraorbital margin more bulky and protruding | Supraorbital margin thinner and sharper edged |
| Ferembach et al. (1979) | Supraorbital margin rounded/very rounded | Supraorbital margin sharp/very sharp |
| Bass (1987) | Upper edges of the eye orbits blunt | Upper edges of the eye orbits sharp |
| Sjøvold (1988) | Supraorbital margin rounded | Supraorbital margin sharp edged |
| Herrmann et al. (1989) | Orbital margin more bulky and smooth | Orbital margin thin and sharp edged |

*TABLE 2. Sex and age at death of the individuals investigated*

| | | Age (years) | | |
|---|---|---|---|---|
| Sex | N | Range | $\bar{x}$ | $\tilde{x}$ |
| ♂ | 67 | 7–85 | 43.5 ± 16.6 | 44 |
| ♀ | 41 | 4–86 | 44.0 ± 21.2 | 45 |

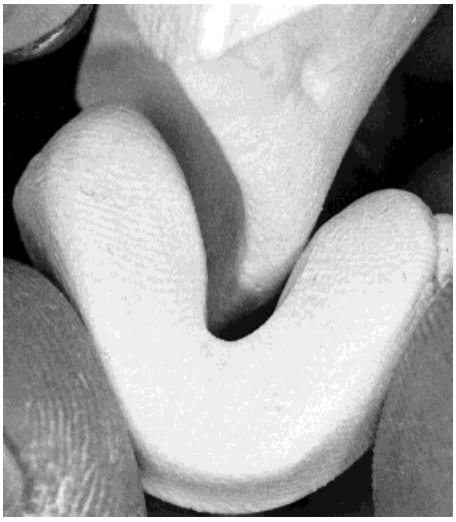

Fig. 1. Preparation of a plasticine impression of the supraorbital margin.

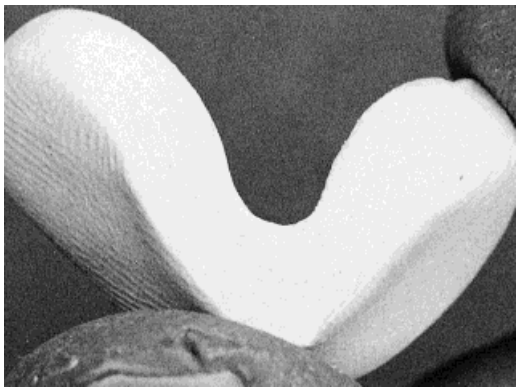

Fig. 2. Plasticine impression.

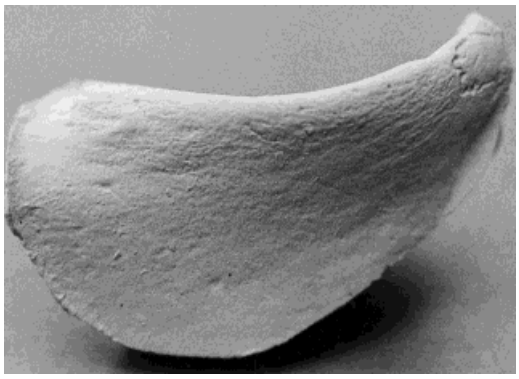

Fig. 3. Plaster of Paris model, ventral (frontal) aspect.

fully and the shape of the supraorbital margin in cross-section assessed along its whole length (see above).

Because the area of the skull around the orbit exhibits various sex-related characteristics, plaster of Paris models of the supraorbital margin were made and labelled without reference to the sex (Figs. 3, 4) to avoid this as a source of observer influence. Plasticine impressions were made from these models and classified on a seven-grade scale (1 = definite male, 4 = uncertain, 7 = defi-

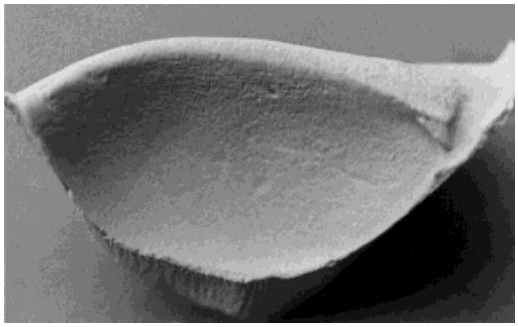

Fig. 4. Plaster of Paris model, dorsal (rear) aspect.

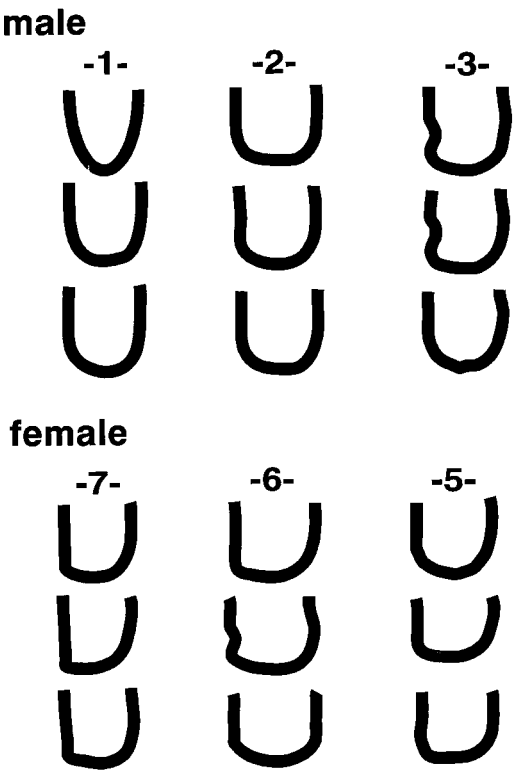


Fig. 5. Examples of the various grades; inner surface of the supraorbital margin on the left side. Grades 1–3, male, trough-shaped profile; grades 5–7, female, angularity of the inner aspect.

nite female) (Fig. 5) by two independent observers with experience in osteology. In grade 1, the profile is evenly rounded, almost symmetrical, and trough-shaped. The width of the trough (i.e., the thickness of the supraorbital margin) is not significant here. In grades 2 and 3, the supraorbital margin is more asymmetrical in cross-section, and indentations of the inner surface with rounded contours are possible, but there is no angulation. Grade 7 represents the typical female form, with definite angularity of the inner aspect and usually marked asymmetry. In grades 6 and 5 there is decreasing angularity. Grade 4 was used to define all forms that could not be classified under the other grades described (*uncertain*). Pearson's chi-squared test was used for statistical analysis.

*TABLE 3. Comparison of the findings of the two observers in the 208 orbits investigated*[1]

| Observer 1 / Observer 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | **23** | | | | | | |
| 2 | 15 | **27** | 6 | | | | |
| 3 | | 14 | **13** | 2 | 2 | | |
| 4 | | 3 | 9 | **14** | 7 | 1 | |
| 5 | | | 5 | 8 | **31** | 3 | |
| 6 | | | | 1 | 5 | **11** | 4 |
| 7 | | | | | | 2 | **2** |

[1] Different sex diagnoses are underlined. The sex diagnosed differed in seven orbits (3.4%).
Bold numbers mark accordance of both observers.

*TABLE 4. Comparison of diagnosed sex with actual sex for orbits with the same sex diagnosed by both observers (n = 170)*[1]

| | Diagnosed sex | | |
|---|---|---|---|
| Actual sex | ♂ | ♀ | Uncertain |
| ♂ | 86 | 10 | 4 |
| ♀ | 12 | 48 | 10 |

[1] $\chi^2_{(2DF)} = 80.6$; $P < 0.0001$.

*TABLE 5. Comparison of the findings in the left vs. right orbit, observer 1 (n = 101)*[1]

| Left / Right | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | **15** | 2 | | | | | |
| 2 | 3 | **13** | 5 | 1 | | | |
| 3 | 1 | 6 | **7** | 2 | 1 | | |
| 4 | | 1 | 1 | **7** | 4 | | |
| 5 | | | 2 | 1 | **14** | 2 | |
| 6 | | | | | 5 | **3** | 2 |
| 7 | | | | | | 2 | **1** |

[1] Different sex diagnoses are underlined. The sex diagnosed differed in three cases.
Bold numbers mark accordance of both observers.

## RESULTS

Of the 216 models prepared, eight had to be discarded because of fractures involving the supraorbital margin, and each investigator therefore assessed 208. Out of the total of 416, 217 were classified as male (grades 1–3)

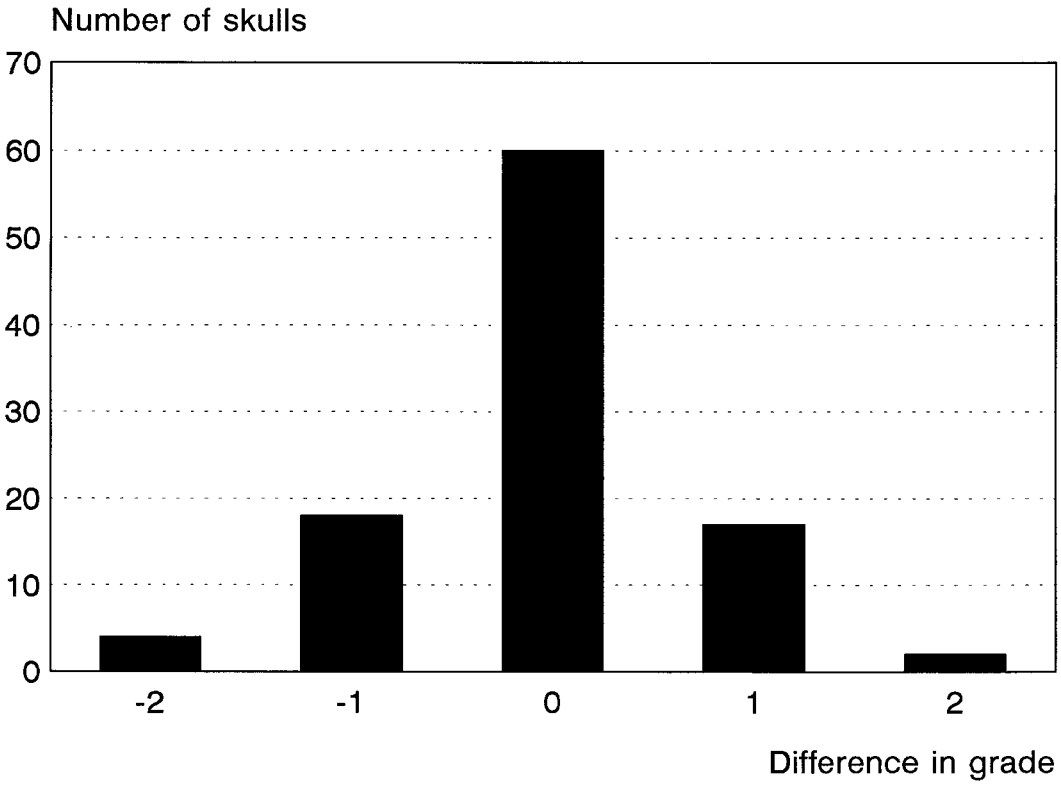


Fig. 6. Difference in grade between the left and right orbits (101 skulls; observer 1).

and 140 as female (grades 5–7), the remainder falling into the category *uncertain* (grade 4).

The method was found to be very reliable, and the sex identified by the two observers differed in only seven orbits (3.4%) (Table 3). The observers' sex diagnosis was the same for 170 orbits. The sex diagnosed by this method was found to be clearly related to the actual sex ($\chi^2_{(2DF)} = 80.6$; $P < 0.0001$) (Table 4).

In 101 skulls, both orbits were intact. Good correlation was found between the left and the right side; the feature investigated was independent of the side (Table 5), and the difference in grades between the two sides was normally distributed (Fig. 6). Thus, the examination of both orbits, rather than just one, was found to provide no additional information ($\chi^2_{(4DF)} = 0.16$; $P > 0.99$) (Table 6).

As expected, the accuracy of the diagnosis was dependent on the degree of prominence of the feature investigated: accuracy increased towards the extremes (i.e., grades 1 and 7). Approximately 80% of the diagnoses were correct (Table 7). When cases classified as grade 4 (uncertain) were also included, the accuracy of diagnosis was found to be 74% (observer 1) or 67.3% (observer 2) (Table 8).

*TABLE 6. Accuracy of diagnosis using one orbit (left) and both orbits (observer 1, n = 101)*[1]

| Diagnosed sex | One orbit | Both orbits |
|---|---|---|
| Correct ♂ | 48 | 48 |
| False ♂ | 7 | 6 |
| Correct ♀ | 27 | 28 |
| False ♀ | 8 | 9 |
| No diagnosis possible | 11 | 10 |

[1] $\chi^2_{(4DF)} = 0.16$; $P > 0.99$.

## DISCUSSION

The supraorbital margin has been included in the features investigated in the identification of sex since Broca (1875) noted

*TABLE 7. Accuracy of diagnosis in relation to grade (n = 208)*

| | Observer 1 | | | Observer 2 | | |
|---|---|---|---|---|---|---|
| Grade | N | Correct | % | N | Correct | % |
| 1 | 38 | 37 | 97.4 | 23 | 23 | 100 |
| 2 | 44 | 35 | 79.5 | 48 | 43 | 89.6 |
| 3 | 33 | 27 | 81.8 | 31 | 21 | 67.7 |
| 1–3 (♂) | 115 | 99 | 86.1 | 102 | 87 | 85.3 |
| 5 | 45 | 33 | 73.3 | 47 | 32 | 68.0 |
| 6 | 17 | 16 | 94.1 | 21 | 17 | 80.9 |
| 7 | 6 | 6 | (100) | 4 | 4 | (100) |
| 5–7 (♀) | 68 | 55 | 80.9 | 72 | 53 | 73.6 |

*TABLE 8. Diagnostic accuracy of the two observers on the basis of examination of one orbit (n = 208)*

| Sex diagnosis | Observer 1 (%) | Observer 2 (%) |
|---|---|---|
| Correct | 74.0 | 67.3 |
| Not possible | 12.0 | 16.3 |
| Incorrect | 13.9 | 16.3 |

a sex-related difference in its form. Various authors have since described sexual dimorphism at this site, although no consistently applied definition has been established (Table 1). Essentially, however, the studies refer to a sharpness of the supraorbital margin in the female without giving more detailed information about sexual dimorphism of this structure or the methods of investigation employed. Pietrusewsky (personal communication) noted the inner aspect of the supraorbital margin in females to be angular but did not confirm this by statistical analysis. We developed a method of assessing this feature by preparing an impression of the supraorbital margin in skulls from an anatomy collection and also detected a sex-related difference (Graw et al., 1997). It was the objective of this study to confirm sexual dimorphism of this feature in modern human skulls and to determine whether it could be of value in the identification of human remains. Our findings show that sexual dimorphism of this structure, which, in the absence of a morphological explanation, is probably genetically determined, can indeed be included in the criteria for identification of sex from the skull. It gives reliable results, is strongly related to sex, and is independent of the side. The accuracy of identifying the sex correctly on the basis of this feature alone is about 70%, which is quite high, considering that figures of 77–92% have been quoted in the literature for evaluation based on all the sex-related features of the skull together (Table 9).

*TABLE 9. Accuracy of sex identification from the skull according to published data*

| Author(s) | Diagnostic accuracy (%) |
|---|---|
| Stewart (1948) | 77 |
| Stewart (1951) | 80 |
| Keen (1950) | 85 |
| Giles (1970) | 85–86 |
| İşcan and Kennedy (1989) (citation) | 80–90 |
| Hanihara (1959) | 90 |
| Rebentisch (1893) | 91.5 |
| Krogmann (1962) | 92 |

Amongst the skulls investigated in this study, five (three female and two male) were from individuals under the age of 18 at the time of death. Although the female skulls were correctly identified as probably female (grade 5), the male skulls were classified in the uncertain group (grade 4). This is consistent with the observation that the male characteristics first reach full development with maturation, so caution is advisable in the assessment of juvenile skulls (Rebentisch, 1893).

Investigations based on large numbers of specimens are currently being undertaken to determine to what extent involutionary processes reduce the reliability of the method in older women and to ascertain whether our findings can be extended to other populations.

## LITERATURE CITED

Acsádi G, Nemeskéri J. 1970. History of human lifespan and mortality. Budapest: Akademiai Kiado.

Bass WM. 1987. Human osteology: a laboratory and field manual. Columbia, MO: Missouri Archaeological Society.

Broca P. 1875. Instructions craniologiques et craniométriques. Paris: Mém.d.l.soc.d'anthrop.de Paris. T II. 2. Serie.

Ferembach D, Schwidetzky I, Stloukal M. 1979. Empfehlungen für die Alters- und Geschlechtsdiagnose am Skelett. Homo 30:1–31.

Giles E. 1970. Discriminant function sexing of the human skeleton. In: Steward TD, editor. Personal identification in mass disasters. Washington, DC. National Museum of Natural History. p 99–109.

Graw M, Haffner HT, Czarnetzki A. 1997. Methode zur Untersuchung des Margo supraorbitalis als Kriterium zur Geschlechtsdiagnose—Reliabilität und Validität. Rechtsmedizin 7:121–126.

Hanihara K. 1959. Sex diagnosis of Japanese skulls by means of discriminant function. J Anthrop Soc Nippon 67:191–197.

Herrmann B, Grupe G, Hummel S, Piepenbrink H, Schutkowski H. 1989. Prähistorische Anthropologie—Leitfaden der Feld-und Labormethoden. Berlin, Heidelberg, New York: Springer.

Hunger H, Leopold D. 1978. Identifikation. Berlin, Heidelberg, New York: Springer.

İşcan MY, Kennedy KAR. 1989. Reconstruction of life from the skeleton. New York: Alan R. Liss.

Keen JA. 1950. A study of the differences between male and female skulls. Am J Phys Anthropol 8:65–79.

Krogmann WM. 1962. The human skeleton in forensic medicine. Springfield, IL: Charles C. Thomas.

Rebentisch E. 1893. Der Weiberschädel. Morphol. Arbeiten II:207–274.

Sjøvold T. 1988. Geschlechtsdiagnose am Skelett. In: Knußmann R, editor. Wesen und Methoden der Anthropologie. Bd I1. Stuttgart, Jena, New York: Gustav Fischer.

Stewart TD. 1948. Medico-legal aspects of the skeleton. I. Age, sex, race and stature. Am J Phys Anthropol 6:315–321.

Stewart TD. 1951. What the bones tell. FBI Law Enforce Bull 20:2–5.

Voigt K. 1941. Geschlechtsunterschiede am menschlichen Schädel. Inaugural dissertation, Kiel.